A PRELIMINARY STUDY OF THE COLEOPTERA ATTACKING WHITE FIR (ABIES CONCOLOR)

by

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Approved by the Department of Forest Entomology

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INTRODUCTION

In recent years, lumbermen, operating within the range of the white fir (Abies concolor Lindley and Gordon) have found it increasingly difficult to leave standing the thirty percent of sound trees which is required by the government in its timber sales. This is due to the abundance of white fir which has been top-killed by the attacks of the bark beetle Ecoptogaster ventralis. Lec. . This injury is common throughout the range of the white fir, as shown by the distribution Chart, Fig. 1.

The required thirty percent means thirty percent of the stand, and in the case of a mixture includes all tree species. These trees must be in a healthy condition and those which are stag-headed cannot be included in the required percentage.

When these stag-headed trees are cut, they are usually found to contain a red heart-rot, which is commonly associated with the dead tops by lumbermen. When the insect has killed the top, the bark dries and peels off thus forming an opening by which

the fungus may enter the tree after the germination of the spores. It would seem quite a logical possibility therefore, that the injury caused by the insect forms a mode of entry for the fungus, because both are associated in nearly every case, and because the fungus requires an injury to the tree before it can penetrate to the wood. I have learned, from Dr. J. S. Boyce of the Osborn Botanical Laboratory, that white fir is a common host of three fungi, which would cause such a heart-rot: the Indian paint fungus, Echinodontium tinctorium; the velvet-topped fungus, Polyporus Schweinitzii, causing a red-brown butt-rot; and the quinine fungus, Fomes laricis, causing a brown trunk-rot. However, the Indian paint fungus is by far the most common and the most important throughout the range of white fir.

Because of this insect damage and the subsequent fungus injury, Mr. J.M.Miller, in charge of the Pacific Slope Insect Laboratory, thought it advisable to make a study of the damage in order to discover as much as possible concerning its nature and the biology of the insect causing it. The writer was assigned to the work during the summer of

1928, and the field studies were made in the period between June 9th and September 22nd at Harvey Valley, Lassen National Forest, Lassen County, California. During the summer of 1929 the writer has substantiated and augmented these findings by investigations in various parts of northern California and southern Oregon.

The work during the summer of 1928 was carried out under the supervision of Mr. J.M.Miller and I am greatly indebted to him for help and constructive criticisms. The insects studied were kindly determined by Dr. M.W.Blackman, Dr. F.C.Craighead and Dr. E.C.Van Dyke.

I also wish to thank Mr.J.A.Beal, formerly in charge of the insect work at the Southern Appalachian Experiment Station, for help received in the field, and Mr. A.H. Mac Andrews of the New York State College of Forestry for suggestions in the writing of this paper.

WHITE FIR (ABIES CONCOLOR)*

White fir is a tree which generally prefers a moderate altitude, occurring at elevations between 6,000 and 11,000 feet, but is most frequently found at altitudes between 7,000 and 9,000 feet. It usually grows on north slopes, and attains its maximum percentage of the stand on benches and the sides of moist canyons with aspects to the north. In the northern part of its range, the tree is less particular in its choice of aspect than in the southern part, where it invariably chooses the north slopes. It thrives on almost all fairly moist, well-drained soils, except heavy clays, but attains maximum growth in fairly deep, rich, moist gravelly or sandy loam soils.

Pure stands of mature white fir covering large areas are never found, although frequently small stands of limited extent and of nearly pure growth occur. Douglas fir, (Pseudotsuga taxifolia Britton) is the most common species to be found in a mixture with white fir; however alpine fir (Abies lasiocarpa Nuttall) Engelmann spruce (Picea Engelmannii Engelmann)

* Sudworth, G.B. 1908. Forest Trees of the Pacific Slope. United States Department of Agriculture Bulletin pp. 120,121.

and aspen (Populus tremuloides Michaux) and P. grandidentata Michaux) are associated with it more or less. It occasionally occurs with western yellow pine (Pinus ponderosa Lawson) and limber pine (Pinus flexilis James).

White fir grows quite rapidly while young, and in youth frequently dominates the stand, however, when the pole stage is reached, it usually gives way in numbers to t e other species in the mixture, so that it later constitutes a much smaller percentage of the maturer stands than it did at the beginning.

White fir is very tolerant of shade throughout its life, and since reproduction is abundant, large dense groups of seedlings are often found. It is a fairly prolific seeder, producing large crops of cones at irregular intervals, ranging from two to four years, but some seed is produced yearly. For this reason, it is one of the first tree species to appear in a burn or cut-over area.

At the present time white fir is one of the less valuable commercial species. In the United States, using the amount cut annually as a basis, it ranks tenth among the softwoods and eighteenth among all the commercial species. The wood is used only for rough

lumber, and to a small extent in box manufacture.

FIELD STUDIES

The Selection of Trees for Study

The original plan of the work included the laying out of a sample plot on which an intensive study of the amount and character of the injury was to be made, but due to the lack of time, this was eliminated from the program, and only two trees were used in the investigation. The first tree was selected because it was a typical example of the injury and showed signs of having been recently killed by insects, as the foliage was just fading from the yellow to the red stage and considerable evidence of insect infestation was present at the base. The tree, twenty-four inches in diameter and one hundred and seventeen feet in height, was felled for examination on June 9, 1928 and was found to be free from rot. Living broods of different insects were found in various stages of development and for this reason the tree was used for brood study until all of the insects had either emerged or died. The

tree was then used for studies of increament, galleries, and insect distribution. The second tree, eighteen inches in diameter and seventy-five feet in height, was in a normal healthy condition and was cut June 8, 1928, to be used as a trap tree from which complete brood records could be obtained. Both trees were located on a moist, well-drained slope with an exposure to the north, in a stand of western yellow pine and white fir, with a dense reproduction of white fir.

Methods Used in Studying the Biology of the Insects

The records of brood development were obtained by removing sections of bark each week and carefully noting the progress of the insects. As the gallery pattern depends on the development of the broods, the study of the gallery patterns of the different insects was left until the broods had completed their development. Each insect was taken separately and notes were made of the gallery pattern, its size, the method of egg deposition, and of larval feeding habits.

For convenience in the study of the distribution of the insects in the tree, the trunk was limbed and arbitrarily marked off into logs, ten feet in length. These logs were numbered consecutively starting with number one at the base of the tree and ending with number twelve at the extreme top. As the tree was one hundred and seventeen feet high, log twelve was only seven feet long. Each log was taken separately and the intensity of the infestation of each insect was recorded. The classification of the intensity of infestation was based on the relative number of galleries present, and graded as abundant, medium, light, or a trace depending on whether the galleries were numerous or few.

THE INSECTS STUDIED

The following insects were studied in the course of the problem:

Ecoptogaster praecepa Lec. Det. by Dr.Blackman Hopk.
U.S. 17908 b.

Ecoptogaster ventralis Lec. Det. by Dr. Blackman Hopk.
U.S. 17907 a.
17908 a.

Gnathotrichus sulcatus Lec. Det. by Dr. Blackman Hopk.
U.S. 17907 f.

Monochamus sp. Det. by Dr. Craighead Hopk.
U.S. 17907 g.

Pityokteines elegans Sw. Det. by Dr. Blackman Hopk.
U.S. 17907 e.
17908 c.

Platypus wilsoni Sw. Det. by Dr. Blackman Hopk.
U.S. 17907 d.

Tetropium abietis Fall. Det. by Dr. Van Dyke Hopk.
U.S. 17907 b.

BIOLOGY OF THE INSECTS

Eccoptogaster praecepa Lec.

Description of the insect:* This insect is 2-3 mm. long, cylindrical, black and shining. The head is thinly clothed with long erect hair. The head of the male is more flattened, more distinctly aciculate and less punctate than in the female, and is also more hairy.

The pronotum is scarcely longer than wide, sides rounded in front and feeble constricted; surface deeply but finely and distantly punctured.

Elytra with numerous rows of rather distant punctures, and showing some traces of very fine striae.

Ventral surface strongly punctured in front, densely and finely behind; declevity perpendicular. Second ventral segment faintly carinate near the tip; fifth ventral concave and as long as the third and fourth united.

Description of the Gallery: The entrance tunnel leads directly into a small nuptial chamber between the bark and the wood, which gives rise to two egg galleries one half to one inch in length, which

* Leconte, J.L. and Horn, G.H. 1876. Rhynchophora of America north of Mexico. Proceedings of the American Philosophical Society. Vol.15 p.373.

progress in opposite directions across the grain of the wood, thus making a forked transverse pattern. The eggs are laid singly in niches and the larvae tunnel separate feeding galleries away from the egg gallery. Both adults and larvae bore between the bark and the wood, etching both quite deeply. (Fig. 13).

Distribution in the tree: This insect attacks only in the branches of the tree, and I have never found it breeding in anything with a diameter smaller than one inch.

Life History: The attack in the branches was first noted on July 11th, at which time only a few eggs had been deposited by the female adults and the attack had apparently just begun. On July 19th, more eggs had been laid, but as yet none had hatched and the tree was not visited again until August 2nd. Young larvae were now present and the parent adults still continued to work in the galleries. Subsequent visits showed that the larvae continued to grow and that the parent adults remained in the galleries, until, when the tree was visited again on August 29th the larvae were nearly mature and only a few parent

adults remained alive. The temperature had been slowly dropping and on two occasions had gone below the freezing point. Development was retarded due to this, and when the last observation was made on Sept. 20th, the brood remained in the mature larval stage and undoubtedly wintered over in this condition.

The death of the parent adults in the galleries and the wintering over of the brood in the larval stage indicate but one brood and one generation per year, with pupation, emergence and subsequent attack taking place in the spring.

Chart of Life History

Date	Parent Adults	Eggs	Larvae
July 11, 1928	•	•	
July 19, 1928	•	•	
Aug. 2, 1928	•		•
Aug. 11, 1928	•		•
Aug. 30, 1928	•		•
Aug. 24, 1928			•
Aug. 29, 1928			•
Sept. 20, 1928			•

Importance of the insect: This insect is purely secondary. It breeds only in the branches of trees which have been killed by other insects or which have been recently cut.

Ecoptogaster ventralis Lec.

Description of the insect: * This insect is 3.75 to 4.5 mm. long, black and shining in appearance. In the male the head has the front flattened, coarsely aciculate, punctured and conspicuously hairy; the female has the front convex, finely punctulate-aciculate and very sparsely hairy.

The pronotum is oblong, a little longer than wide, slightly narrowed in front, feebly rounded on the sides, moderately punctured, more finely on the disc than at the sides.

In the male the elytral punctures are rather small, somewhat coarser but only slightly rugose at the base; those of the striae and interspaces being equal in size and distance, and bearing very small greyish hairs. The female has the elytra rather coarsely and rugosely punctured at the base and much more coarsely punctured throughout than the male.

The venter is concave; strongly but not densely punctured; second segment strongly margined in front and with a divided median tooth-like carina at the caudal margin. In the female the second segment only occasionally has a minute caudal granule.

* Zimmerman, C. and Lecoute, J.L. 1868. Synopsis of the Scolytidae of America, north of Mexico, with Appendix. Transactions of the American Entomological Society. Vol. 2 p.157

Description of the gallery: The entrance tunnel leads directly into two egg galleries two to six inches long, which form a forked transverse pattern. The eggs are laid singly in niches along both sides of the gallery, and the larvae bore individually at right angles to the egg gallery. Both adults and larvae etch both the bark and the wood quite deeply. This pattern is very similar to that of Pseudohylesinus grandis and is distinguished from it by the characteristic curve of the gallery at the juncture of the two galleries (Figs. 12 & 16.). The gallery of P. grandis is also of the forked transverse type, but the two egg galleries unite to form a straight line (Fig. 15).

Distribution of the insect in the tree: In the recently killed tree which was cut for analysis, the heaviest attack of this insect was found in logs eleven and twelve at the top of the tree and a gradual decrease in intensity was apparent until the attack disappeared entirely, the lowest gallery being two feet from the base of the tree. The trap tree, on the other hand, showed a very heavy attack throughout its entire length. Nevertheless, there is a distinct preference shown for the upper portions

of the tree, as shown in Fig. 2. It was also noted that galleries were most numerous on eastern and north eastern exposures of the trunk.

Life History: Parent adults, eggs and first stage larvae were found in the trap tree on July 11th. By July 19th most of the eggs had hatched and the young larvae had proceeded a short distance in their feeding galleries. The larvae were from one half to three quarters grown on August 3nd, and the parent adults still remained in the tree, the females were tunneling and laying eggs and the males were guarding the entrance hole. On August 11th, the same condition prevailed. By August 20th, the larvae were from three quarters to full grown and the parent adults continued to work in the tree. On August 29th, few parent adults remained alive and the majority of the larvae were full grown. At this time the temperature had dropped considerably and had reached the freezing point on two occasions. No further development was noted when the work was concluded in the latter part of September and the larvae undoubtedly wintered over in this stage.

Old attacks of this insect were found in the analyzed tree in which a number of parent adults were

found dead in the tunnels and blocking the entrance holes. This indicates that emergence and subsequent attack occurs in the spring and that only one brood and one generation occurs each year.

I believe that the odd shaped galleries found in white fir branches and shown in Fig. 19 are made by this insect while feeding before starting the egg gallery in the trunk. I have found Eccoptogaster praeceps feeding in pairs in the smaller branches (Fig. 18) of white fir and believe that the larger galleries in the larger branches can be attributed to the feeding of E. ventralis.

Chart of Life History

Date	Parent Adults	Eggs	Larvae
July 11, 1928	*	*	*
July 19, 1928	*	*	*
Aug. 2, 1928	*		*
Aug. 11, 1928	*		*
Aug. 20, 1928	*		*
Aug. 29, 1928	Few		*

Importance of the Insect: This is the insect which caused the killing of the top and the ultimate death of the tree, and is therefore a primary insect in that it attacks and kills living trees. However, two or more attacks are required before the tree is finally killed. The first attack results in the death of the top and the subsequent attacks seal the fate of the tree.

Gnathotrichus sulcatus Lec*

Description of the insect** This species is 3.6 to 3.8 mm. long, cylindrical, slender and blackish brown. The front is convex, with a median carina on the vertex, very sparsely punctured, basal median area strongly convergently aciculate, the lines meeting at the slight median emargination of the epistoma which bears a minute, acute point at the base of which the median lines terminate. The antennal club and funicle with a few long, marginal hairs in the female, with antennal pubescence normal in the male.

The pronotum nearly one-half longer than wide, sides slightly converging from the base and feebly rounded, tip strongly rounded, surface rough and sparsely hairy before the middle, granules fairly coarse near the tip, behind the middle sparsely punctulate.

Elytra finely and densely rugose, distantly punctulate in rows, with a few long hairs behind the middle, posterior declivity with a deep depression along the suture.

* Described by Leconte as Cryphalus
** Zimmerman C & Leconte, J.L. 1868. Synopsis of the Scolytidae of America, north of Mexico, with Appendix. Transactions of the American Entomological Society., Vo. 2. Page 155.

Description of the Gallery- This insect is a true ambrosia beetle and the adults, after passing through the bark, bore directly into the wood and excavate a perfectly cylindrical tunnel which branches after entering the wood a short distance. The female deposits the eggs singly in niches along the walls of the gallery, and upon hatching the larvae enlarge these niches to form short side tunnels known as "larval cradles" which are slightly longer than the larvae themselves. These cradles have their long axis parallel to the grain of the wood. The borings are extruded from the holes in the form of a fine, mealy powder which distinguishes these galleries from the galleries of Platypus, because the borings of the latter insect are extruded in the form of minute white splinters. The eggs are packed in with boring-dust and excrement. Both the adult galleries and larval cradles are stained black by a fungus which grows in the tunnels and upon which the larvae and adults feed. Parent adults were collected on June 9, 1928.

Distribution of the insect in the tree- This insect was found only in the upper-central portion of the trunk, as a light attack in log ten, which decreased to a trace in log five. This location is possibly due to the smaller diameter of the trunk which allows for an easier excavation of this particular type of gallery.

Importance of the insect- Attacks are found in weakened and dying trees and in recently cut timber. Attacks in logs cut for lumber are particularly serious because of the stain caused by the fungus which lowers the value of the lumber. The powdery borings of this species are often found on scars caused by fire.

Monochamus sp.

This insect was found only in the larval stage, and was determined by Dr. Craighead as the larva of Monochamus. Young to mature larvae were found on September 12th, 1928. The gallery, as far as completed, was merely an irregular tunnel between the bark and the wood, and varied in width (Fig. 16). I believe that these were the larvae of M. oregonensis, as this insect is quite abundant in the locality, and I have often found it ovipositing in freshly cut fir trees.

The attack of this insect was not abundant at any point in the tree. It fluctuated from a trace to a light attack from log one to the end of log eleven.

The insect attacks only dead and freshly cut trees and can cause very serious damage to logs which have been cut for lumber and allowed to remain in the open for more than one season without being sawed. The larval mines riddle the wood, which can then be used, if at all, for only an inferior grade of lumber.

Pityokteines elegans S W

Description of the insect * - This species is 2.5 mm. long. The female has the front flattened, densely finely granulate, densely clothed with very long incurved orange-colored hairs; the antennal club wider than long, first suture nearly straight except at the sides, the distal oblique part strongly depressed.

The pronotum is slightly longer than wide, with the sides feebly arcuate on the basal half; front margin broadly rounded, rather closely separate in front; rather sparsely and finely punctured behind, with a wide smooth median space; apical margin fringed with very long orange hairs similar to those on the front of the head. The elytra have the sides paralled, the apex

* Swaine, J.M. 1916 New species of the Family Ipidae, Part 3. Canadian Entomologist. Vol 48. pp 182-83.

semicircularly rounded, the striae finely regularly impressed, the sutural striae somewhat deeper and wider than the others; interspaces wide, moderately convex on the disc, smooth except near the declivity; declivity very steep, suture raised, the declivital face deeply and broadly sulcate on each side.

The male has the front convex, rather coarsely punctured, more sparsely behind, more densely near the epistoma, the punctures slightly granulate, sparsely hairy; the pronotum without the fringe of long hairs from the front margin; elytral declivity deeply concave.

Description of the gallery: The entrance tunnel opens into a flat nuptial chamber, lying between the bark and the wood, from which radiate usually four egg galleries which are from one to one and a half inches long. This forms the radiate or star-shaped pattern. The tendency seems to be for the egg-tunnels to parallel the grain of the wood more or less. The eggs are deposited in niches along the sides of the gallery, and the larvae bore separate feeding tunnels.

Distribution of the insect in the tree: The attack first appeared as a trace in log four, grew to

medium frequency in logs eight, nine and ten, then diminished again to a trace in log twelve. This species prefers the portion of the tree where the bark is medium in thickness, thus making the entrance less difficult, and yet offering sufficient protection to prevent excessive drying.

Life history: The attack had apparently just begun in tree number one when it was cut for analysis, and the parent adults were just depositing eggs. Eight days later, June 17th, none of the eggs had hatched. On June 27th, parent adults and young larvae were present. By July 11th, a number of pupae had appeared although most of the brood was still in the larval stage. The parent adults had left the tree, to apparently raise a second brood, because a new attack consisting of parent adults and eggs appeared in the trap tree on July 11th. This attack soon died out, however, due to the intensity of the E. ventralis attack. On July 19th, pupae were abundant in tree number one, and larvae were scarce. On August 2nd, all the larvae had transformed to pupae and a few new adults had appeared. By August 11th, some emergence had taken place and by August 20th emergence was

complete. This would indicate two broods with two generations per year.

Chart of the Life History

Date	Parent Adults	Eggs	Larvae	Pupae	New Adults	Emergence
June 8, 1928	*	*				
June 17,1928	*	*				
June 27,1928	*		*			
July 11,1928			*	*		
July 19,1928			*	*		
Aug. 2,1928				*	*	
Aug. 11,1928					*	* complete
Aug. 20,1928						

Importance of the insect: This is a true secondary insect as it attacks only after the tree has been killed by another agency. Also, the galleries cause no injury to the wood.

Platypus Wilsoni Sw.

Description of the insect: * This species is 5.5 mm. long, 1.3 mm. wide, shining, with the pubescence inconspicuous above, except on the front, and about the declivity.

The female has the whole front broadly and deeply excavated, densely granulate-punctate, and clothed with long yellow hairs; vertex with a narrow median carina.

The pronotum is one fifth longer than wide; the sides subparallel, with a broad and deep emargination just behind the middle;the hind angles rounded; the disc irregularly depressed about the median line, with a median sub-oval area on the caudal half very finely and densely punctate, this densely punctured area divided on the median line by a fine black, slightly impressed line.

The scutellum is strongly depressed, very elongate and very sharply acuminate.

The elytra are slightly more than twice as long as wide, about as wide as the pronotum; apex sub-truncate; declivity very short and nearly perpendicular; striae distinctly impressed, with individual punctures narrow and elongate; interspaces convex and smooth, the

* Swaine, J.M. 1916. Platypus wilsoni — a new species of Platypus from British Columbia. Canadian Entomologist Vol. 48, pp. 97-100.

third interspace strongly widened at the base, swollen and densely finely granulate.

The male has the epistomal margin more deeply though very broadly emarginate dorsally, with the inferior lobe more prominent; the elytra with the sides parallel for three fourths the length, then strongly arcuately narrowed to the individually strongly produced apices; strial punctures notably coarser than in the female.

Description of the gallery: This is a true ambrosia beetle, the adults excavate a cylindrical tunnel about ten to fifteen inches in length, which goes through the bark and directly into the wood. This tunnel is straight and unbranched and is lined with a characteristic fungus which stains the wood black. This fungus serves as food for the larvae and is eaten to a lesser degree by the adults. Boring dust, in the form of minute splinters, is ejected from the gallery entrance and lodges in crevices of the bark.

Distribution of the insect in the tree: Frequent attacks of this insect were found in log one at the base of the tree and these gradually diminished in abundance until only a trace was found in log nine, or

ninety feet from the ground. Thus, the insect seems to concentrate its attack upon the base of the tree.

Life History: The rearing notes for this species are necessarily incomplete, since attacks were not started until late August and early September. However, some notes were taken as to the method of egg laying. The female deposits oblong, pearly-white eggs loosely in the bottom of the tunnel, the eggs numbering from two to eleven in those examined. Chamberlain,* states that the larvae of this species cut cradles shortly before pupating.

Importance of the insect: This insect is very abundant and injurious in the Pacific northwest and in southern British Columbia. It attacks all conifers with the exception of Thuya and Chamaecyparis, but is found most frequently in Pseudotsuga, Tsuga, and Abies. Dying and badly weakened trees and freshly cut logs are usually selected for attack. Attacks made in logs cut for lumber are especially injurious because of the stain caused by the fungus in the gallery.

* Chamberlain. Bark Beetles Infesting Douglas Fir. Oregon Agricultural Experiment Station Bulletin. No. 147

Pseudohylesinus grandis Sw.

Description of the insect: * The female is an elongate-oval species, rather stout, 3.5 mm. long and 1.8 mm. wide; clothed with scales and short hairs, the elytra variegated.

The head has the front convex above, the transverse impression wide, with a narrow, acute, median carina extending to the level of the anterior angle of the eyes; the front clothed with numerous short, stout erect hairs; the vertex and a band behind the eyes with tufted hairs; the lateral margins of the epistoma acute and over-hanging the deep antennal scrobes.

The pronotum is distinctly narrower than the elytra, one fourth wider than long, the sides moderately arcuate; the front margin strongly rounded; the disc transversely impressed in front, densely rather roughly not so coarsely punctured; the punctures shallow and irregular in size; with a narrow shining median carina; densely clothed above with fringed scales interspersed sparsely with short suberect hairs; the scales passing into plumose hairs at the front and hind margins, and the scales light colored except in a large irregular patch on each side of the median line behind, on which they assume the ground color.

* Swaine, J.M. 1918. Canadian Bark-Beetles. Part I. Dominion of Canada, Department of Agriculture Bulletin no.14 p.32

The elytra are distinctly wider than the pronotum, one half longer than wide; strongly rounded at the base, and margined with close, wide crescentic serrations; the sides paralled to the middle then strongly narrowed and narrowly rounded behind; the striae narrow, faintly impressed on the disc, more strongly on the sides, the strial punctures small, shallow; the interspaces wide, faintly convex, more noticeably behind; the ground color a deep rich brown to nearly black; with the scales on sections of each interspace grey to yellowish, each interspace variegated individually; the light patches forming a wide V-shaped marking about the middle of the elytra; the interstrial asperities larger and more acute on the sides of the declivity, the ninth interspace carinate and dentate behind about the declivital margin.

The male differs in the shape of the pronotum, which is very much wider than long, strongly rounded on the sides behind, very stron ly constricted in front of the middle, strongly rounded on the narrow front margin, and has the front and sides with the scattered coarse punctures sparsely rather coarsely naperate.

Description of the gallery: This gallery is very similar to that of Ecoptogaster ventralis and is distinguished from it as described above. The entrance tunnel leads directly into two egg galleries with no apparent nuptial chamber present. The two egg tunnels form a forked transverse pattern and the eggs are deposited singly in niches along the sides of the gallery which is about two inches long. Each larva bores its own feeding gallery. All galleries engrave the wood and the bark quite deeply (Fig. 15.)

Distribution of the insect in the tree: The attack was heaviest on west and south west exposures of the trunk. It appeared as a light attack in log five, grew to abundance in log eight, then gradually diminished to a trace in log eleven. This insect, like Ecoptogaster ventralis, prefers the upper portions of the tree.

Life History: Parent adults were working, and young larvae had already developed in tree number one when it was felled for examination. On June 17th, conditions were the same and it was noted that the attack was dying out on the upper side of the log. As the broods of other insects were not affected, this

was probably caused by high temperature or excessive dryness, due to exposure of the log to the sun; and seems to indicate that Pseudohylesinus grandis will reach the mortality point at a lower temperature than the other insects in the tree.

It was difficult to follow the life history of this brood, because the high temperature and other adverse ecological conditions caused a retardation in development and eventually the ultimate death of the entire brood. On the next three visits, little development was noted, parent adults were present in the galleries, and the larvae had proceeded but a short distance from the egg gallery. On August 2nd, there were no living parent adults in the tree. Most of the galleries contained dead adults,but a few had been completely vacated. On August 11th, most of the larvae were in the prepupal stage and a few pupae were found. By August 20th, a few new adults had appeared, but the pupal stage was the most abundant. At this point the attack had been entirely killed out, but emergence would either have taken place in the fall or the new adults would have wintered over to emerge and attack in the spring. Nothing definite can be said concerning the number of broods and

generations because the parent adults and new adults were killed in the tree.

Chart of Life History

Date	Parent Adults	Eggs	Larvae	Pupae	New Adults
June 9, 1928	*	*	*		
June 17,1928	*		*		
June 27,1928	*		*		
July 11,1928	*		*		
July 19,1928	*		*		
Aug. 2,1928			*		
Aug. 11,1928			*	*	
Aug. 20,1928				*	*

Importance of the insect: This is a secondary insect, and attacks only dying trees. It is very seldom found in logs which have been cut for lumber, due to their exposed condition. The attack does no damage to the tree, as the gallery engraves only the outer surface of the wood.

Tetropium abietis Fall

Description of the insect*- Length 13 to 17 mm.; width 3.5 to 4.5 mm. Dark brown varying to pale brown, but concolorous throghout. Head and prothorax shining and not densely pubescent, the former numerously simply punctate with distinct median sulcus, the latter quite strongly granulate-punctate and with a strongly marked and oval impression, which is narrowly smooth and slightly elevated at middle posteriorly. Elytra wider than the prothorax, parallel or slightly narrowed posteriorly, with the usual fine and short appressed pubescense; luster dull, the discal raised lines distinct but fine; sculpture exceedingly fine, subgranulose corrasperate punctate. Shining beneath, finely punctate and with longer, sparser pubescence.

The male has the antennae about five-sixths as long as the body; femora stout; pygidium obliquely narrowed behind, the apex rather broadly truncate.

The female has the antennae scarcely longer than half the length of the body; femora less stout; pygidium with apex broadly evenly rounded in a nearly circular arc.

*Fall, H.C. 1913. A new Tetropium, two new Bruchidae, with brief notes on other Coleoptera. Entomological News. Vol. 33 page 320.

Description of the gallery: The larva first bores between the bark and the wood, excavating a shallow irregular winding gallery, which gradually increases in width as the larva develops. The larva then enters the wood and excavates a winding gallery, oval in cross section. When mature the larva bores to the surface of the wood and pupates between the bark and the wood.

Distribution in the tree:- An abundant attack was found in logs one, two and three and this gradually diminished to a trace in log seven. The insects prefer the base of the trees where the bark is thickest.

Life History:- Brood records for this insect were obtained from the tree cut for analysis. On the date of felling, (June 9th) mature larvae, pupae and one adult were found. On June 17th, a few larvae remained, pupae were the most common, and several new adults were found. One June 27th, a few larvae remained, pupae were the most common, and several new adults were about equal in number and by July 11th complete emergence had taken place.

Emergence and attack thus occur in early summer, but whether the life cycle requires one or two years for completion is uncertain.

Chart of Life History

Date	Larvae	Pupae	New Adults	Emergence
June 9, 1928	*	few	one	
June 17,1928	few	*	*	
June 27,1928		*	*	
July 11,1928				*

Importance of the insect: This insect enters only dead and dying trees and fresh logs cut for lumber. The amount of injury to saw logs is uncertain, due to the fact that no study was made of the depth of the gallery. If the beetle enters the heartwood, the value of the lumber is greatly lessened, but if the injury is restricted to the sapwood, the galleries will be cut off in the slabs and edgings.

INCREMENT STUDIES

Method of Obtaining Increments

The object of this portion of the study was to ascertain when the top of the tree was killed and to correlate this, if possible, with the time and region of attack.

For this purpose the tree was again arbitrarily marked into logs of ten feet, as was done in studying the distribution of the insects in the tree. The logs were numbered the same, starting with number one at the base of the tree, and ending with number twelve at the top.

A small block of wood, which included radial growth for approximately the last thirty years, was removed from each log at a point midway between the two extremeties of the log. This was done with an axe, and each increment block was labeled so that its position in the tree would be known when growth studies were made in the laboratory.

Procedure in Studying Increments.

The increment blocks were smoothed, and the annual rings were measured with the increment measurer,

or increment comparator, which was devised by Dr. F.C.Craighead for use in the Bureau of Entomology. Because it was known that the tree had not been killed as an entity, but had suffered subsequent attacks in different years, which caused the cessation of growth in various parts in these years, it was necessary to find a constant ring which could be used as a guide. That is, an annual ring which was either consistently large or consistently small throughout the entire length of the tree, so that, recognizing this ring in any increment, the year of formation of the other rings could be determined, and thus the year in which the growth stopped.

For this purpose, the ring formed in 1924 was chosen, because it was the smallest ring to be found in the increment blocks.

Each ring in all the increment blocks was measured and the width was recorded on the chart under the proper year, as shown by the position of the 1924 ring.

Chart of Increments

Log	Year									
	1927*	1926*	1925*	1924*	1923	1922	1921	1920	1919*	1918
1			.38	.30	.48	1.12	1.08	1.11	.92	1.23
2			.72	.48	.51	1.12	1.05	1.40	.96	1.22
3					Missing					
4			.47	.35	.47	1.10	1.02	1.26	.83	.98
5			.40	.43	.98	1.09	1.05	1.38	.99	1.18
6	.08	1.00	.80	.57	.96	.93	1.41	1.03	1.28	1.12
7	1.08	.82	.92	.62	1.32	1.18	1.53	1.11	1.33	1.52
8	.89	.89	.75	.61	1.20	1.15	1.42	1.14	1.49	1.45
9	.66	.95	.82	.76	1.73	1.42	1.40	1.11	1.63	1.58
10	.80	1.27	1.32	.66	1.54	1.25	1.22	1.18	1.82	1.66
11		.74	.68	.40	1.32	1.22	1.03	.76	1.09	1.35
12	—	.90	1.11	.65	1.20	2.31	2.04	1.72	1.80	2.29
	3.51	6.57	8.37	5.83						
	70	94	76	53						

Measurements in millimeters
* years of attack as shown by old scars in cross-sections of log (Figs. 20 and 21).

Conclusions from Increment Studies

Plant physiologists have shown that when a tree is girdled below the foliage, it will continue to form annual rings above the point of girdling, but not below. Thus, from the chart, it can be seen that the

tree suffered a severe girdling attack on the lower fifty feet of the trunk in 1925, causing the radial growth to cease in that section during that year.

The chart also shows a cessation of growth in the upper seventeen feet of the tree in the year 1926. This might be due to one or a combination of factors which eventually caused the death of that region. In the first place, a heavy infestation of the insect occurred in that year, which would increase the already weakened condition of the tree. Secondly, plant physiologists agree that there is a greater evaporation from new tissue than from old. Thus the transpiration rate would be higher in the rapidly growing, upper branches of the tree, and coupled with this, is the inadequate water supply from below, due to the girdling in 1925. This would tend to dry out the higher portions of the tree, and hasten the death of the upper trunk.

The tree was completely killed in 1927, as shown by the lack of growth rings after that year.

ADVISABILITY AND METHODS OF CONTROL

Under present economic conditions, the value of white fir does not warrant the expense connected with western control measures. However, white fir may rise in value, as did other unimportant lumber trees, due to changing economic conditions; and under these circumstances, it will be well to have control measures in mind, which can be applied. It should also be remembered that a change in the composition of the stand, which would result from the death of the white fir, would cause secondary changes such as a change in soil composition. Whether these changes would be beneficial or detrimental, cannot be said, and until more is known concerning this subject, it is advisable to keep the forests as near natural as possible.

Several controls can be used, depending upon varying conditions. Probably the simplest and least expensive, is that based upon the management of the forest. Scolytus ventralis is a weak primary insect, and if the forest is so managed, that the white fir is kept in a vigorous growing condition, the

vitality of the tree will be sufficient to throw off attacks. In connection with this control, it will be advisable to dispose of all the larger slash on cutting operations, because E. ventralis breeds very readily in this material.

The felling and peeling of infested trees which contain living broods would also be effective, although much too expensive under present conditions. In this method, a cruising crew investigates the infested area, and marks and maps the infested trees. These maps are turned over to the control crew, which proceeds to cut and peel the mapped trees. Peeling, without burning, would be sufficient in this case, because the larvae bore and pupate between the bark and the wood; and thus more exposure would kill the brood due to the drying effect of climatic agents.

For those secondary insects which destroy saw logs for lumber purposes, the best procedure is to prevent attack. This can be done by storing the logs in the mill pond, utilizing the logs as soon as they are cut, or, if the logs must be left in the woods, peel them.

SUMMARY

1 - The following insects were found attacking white fir: Ecoptogaster praeceps, Ecoptogaster ventralis, Gnathotrichus sulcatus, Monochamus sp., Pityokteines elegans, Platypus wilsoni, Pseudohylesinus grandis, Tetropium abietis.

2 - Ecoptogaster praeceps attacks only the branches and produces but one brood and one generation per year. Pupation, emergence and attack take place in the spring. This is a secondary insect.

Ecoptogaster ventralis prefers the upper portions of the trunk with a northeast exposure, and produces but one brood and one generation per year. Emergence and attack occur in the spring. This is a primary insect.

Gnathotrichus sulcatus attacks the upper-central portion of the trunk and is a true ambrosia beetle. The galleries appear in the wood a small holes, stained black by the fungus, thus lowering the value of the lumber. This is a secondary insect.

Monochamus sp. was probably M. Oregonensis a secondary insect which breeds in the slash and saw logs stored in the woods. Larval galleries are cut deeply into the wood and reduce its value for lumber.

Pityokteines elegans prefers the central portion of the trunk and produces at least two broods and two generations per year. This is a secondary insect.

Platypus wilsoni is a true ambrosia beetle which prefers the base of the tree for its attack. The gallery is straight and unbranched, and the eggs are laid loosely in the bottom of the tunnel. This is a secondary insect. Attacks made in logs cut for lumber are especially injurious because the insect introduces a fungus which stains the wood.

Pseudohylesinus grandis prefers the upper portion of the trunk with a south and west exposure.

Tetropium abietis is a secondary wood borer which prefers the base of the tree.

3. Increment blocks showed that the lower fifty feet of the tree was killed in 1925, the upper seventeen feet in 1926, and the entire tree in 1927.

4. Controls are not advisable under present economic conditions.

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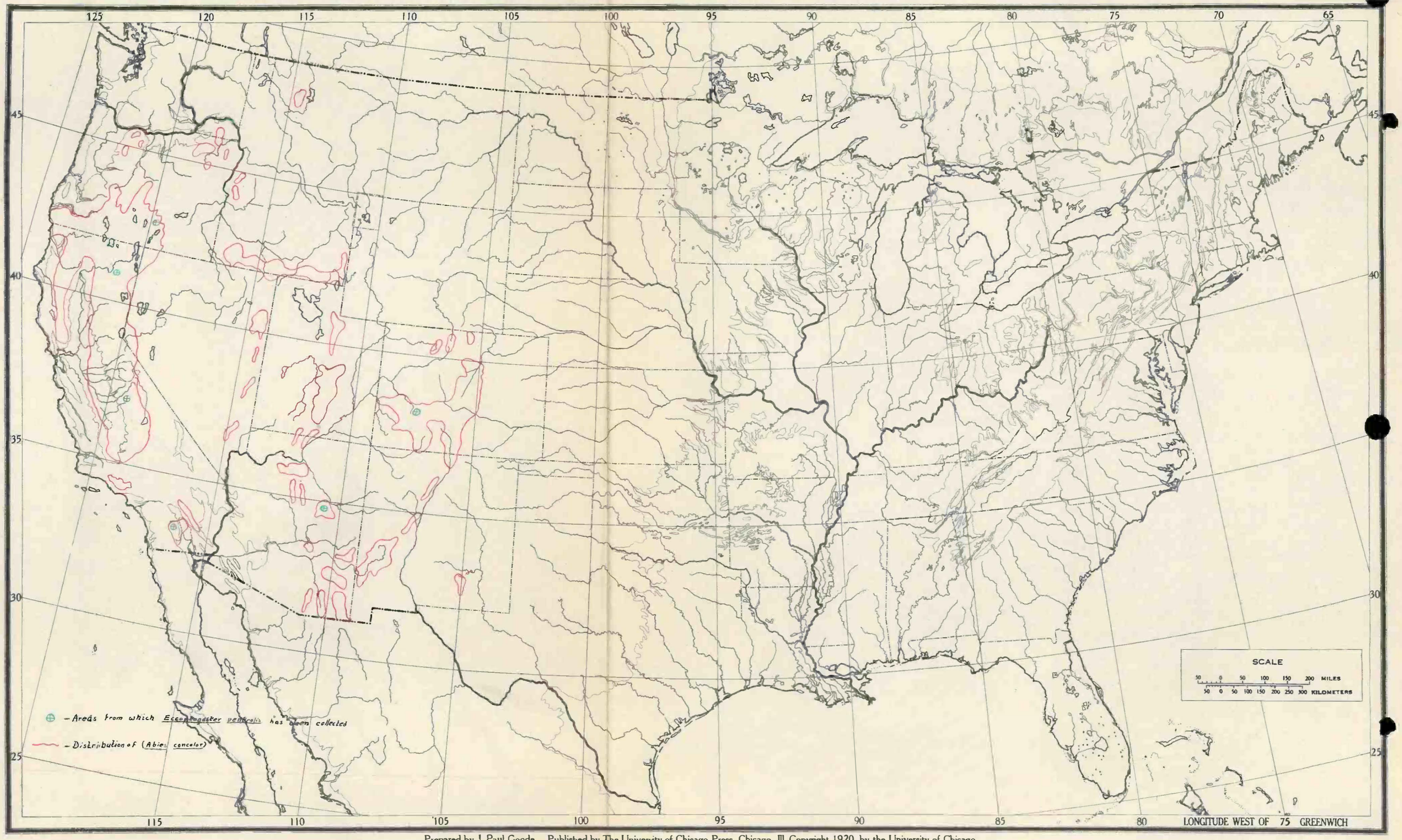


Prepared by J. Paul Goode. Published by The University of Chicago Press, Chicago, Ill.

Fig. 1

Fig. 2

The distribution and the intensity of attack of the insects found in the analyzed white fir tree. The vertical axis shows the portion of the tree which is attacked and the horizontal axis shows the intensity of the attack. Lines extending completely across the tree indicate a heavy attack; three quarters of the distance a medium attack; half the distance a light attack, and one quarter of the distance or less indicate just a trace.

Fig. 2 – Showing the Distribution of Insect. in White Fir Killed by Eccoptogaster ventralis

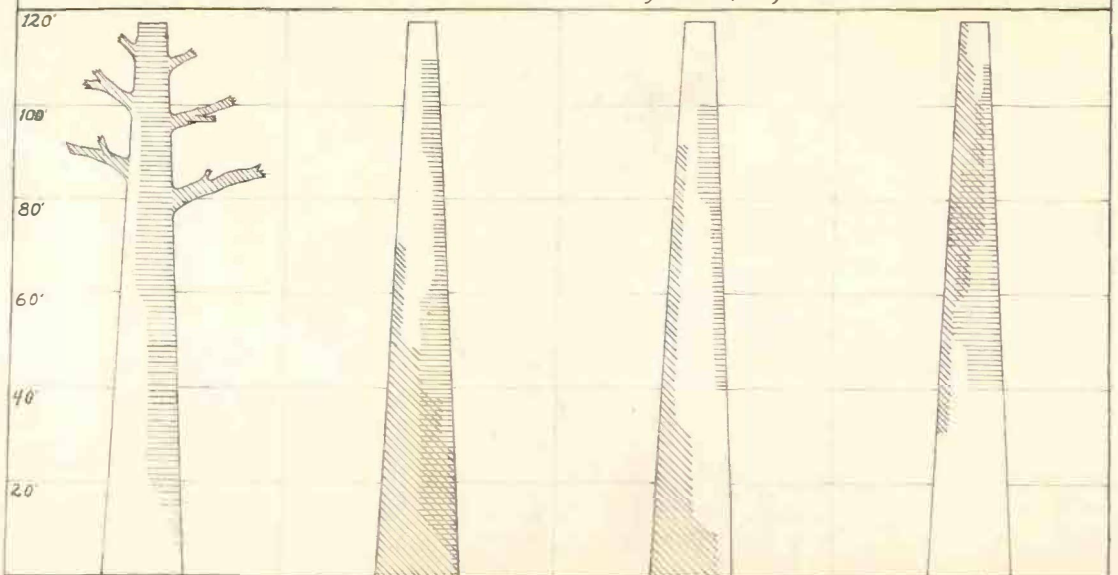


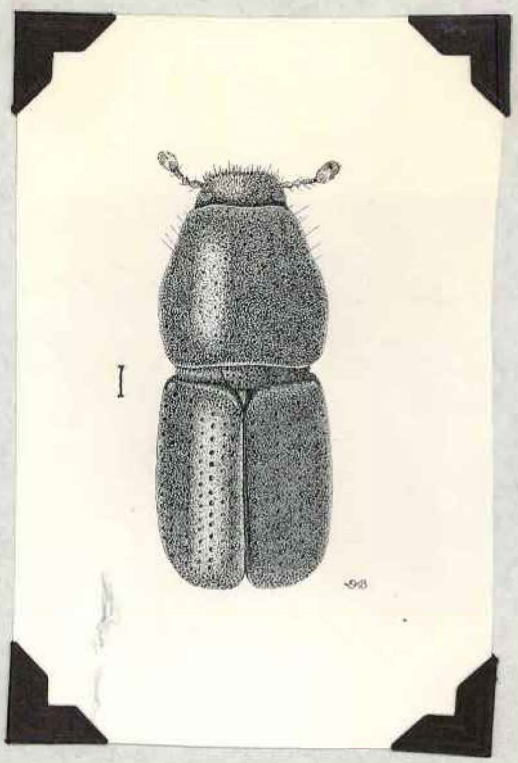
Fig. 3

Ecoptogaster ventralis Lec. Dorsal view.

E. ventralis and E. praeceps appear the same in dorsal view, the only difference being in size.

Fig. 4

Ventral declivity of Ecoptogaster praeceps Lec. E. ventralis has the second ventral segment moderately shining and sparsely punctured. E. praeceps has the ventral declivity opaque, and very closely punctured.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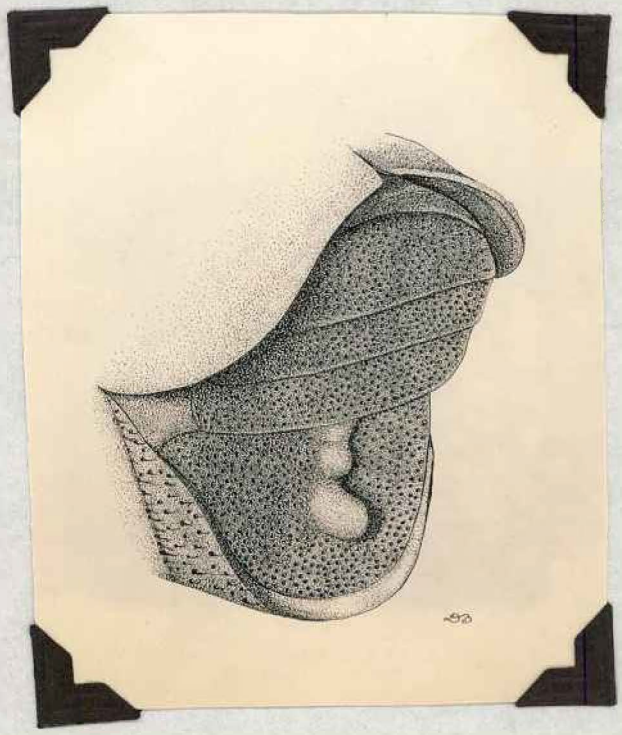


Fig. 5

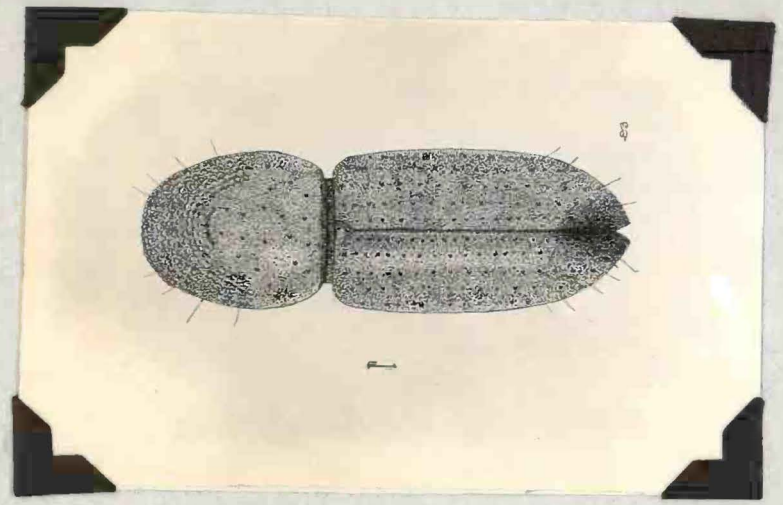
Gnathotrichus sulcatus Lec.

Dorsal view.

Fig. 6

Pityokteines elegans Sw.

Dorsal view.



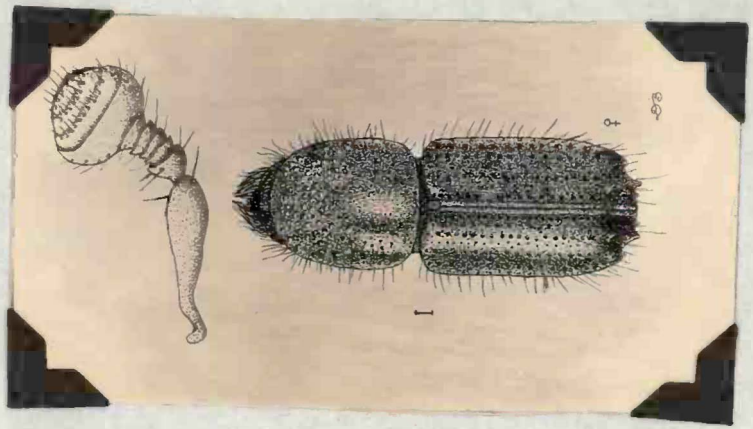


Fig. 7

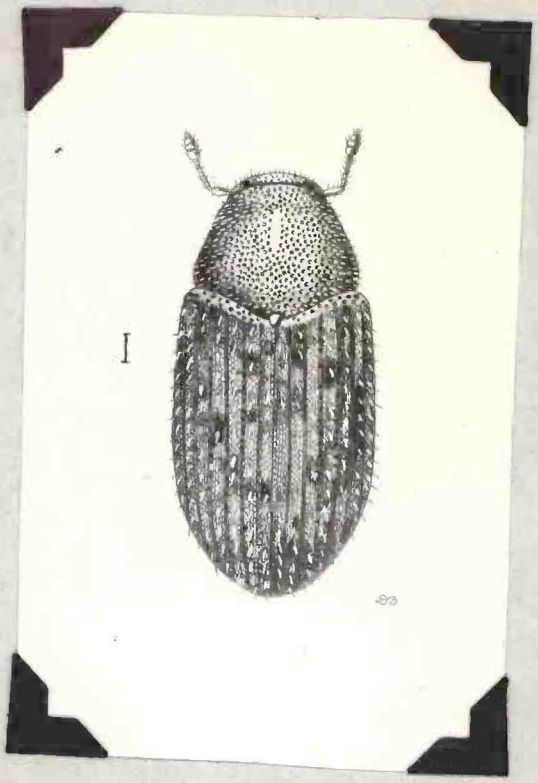
Pseudohylesinus grandis Sw.

Dorsal view.

Fig. 8

Tetropium abietis Fall.

Dorsal view.



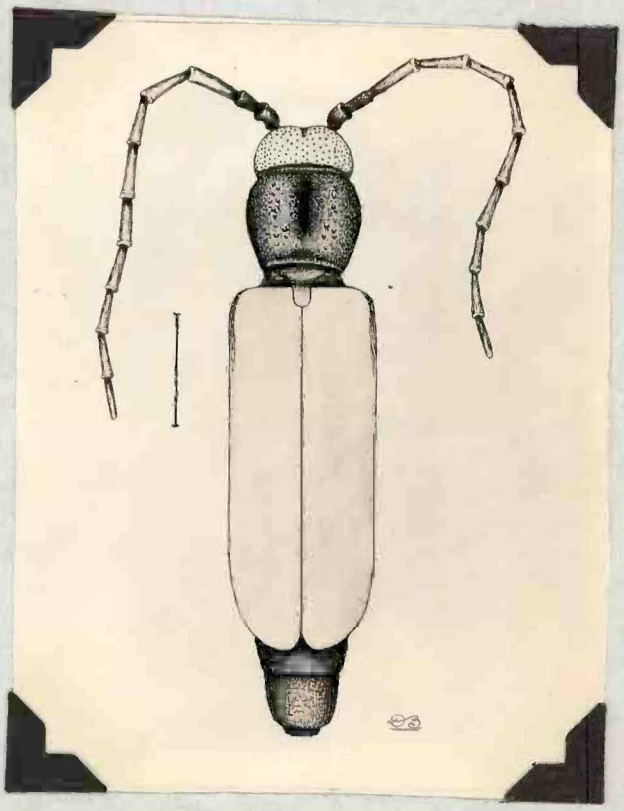


Fig. 9

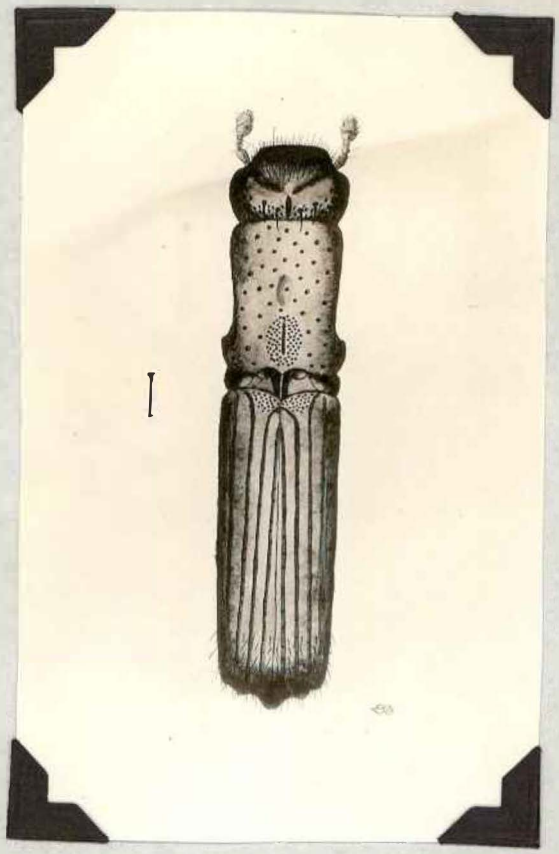
Platypus wilsoni Sw.

Dorsal view

Fig. 10

Platypus wilsoni Sw.

Dorsal view of male declivity.



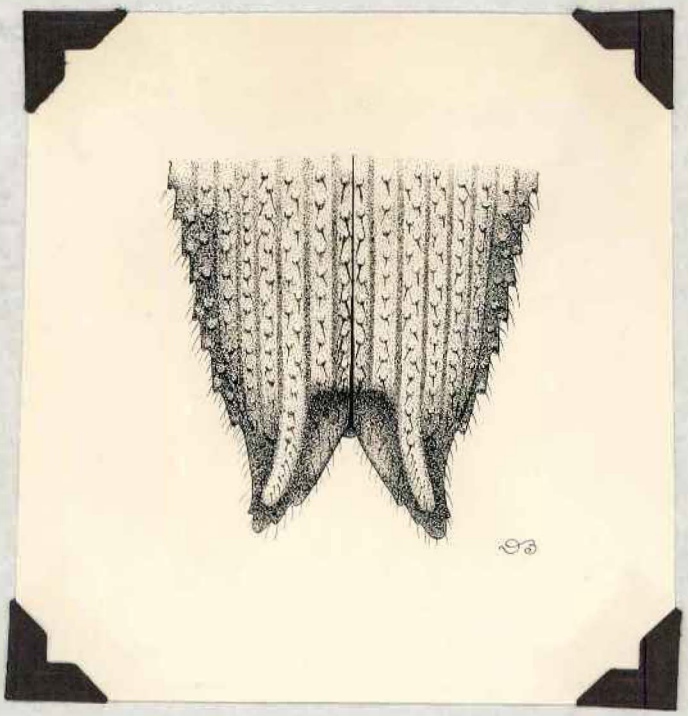


Fig. 11

White fir trap tree, showing larval and adult engravings of Eccoptogaster ventralis Lec.

Fig. 12

Closer view of trap tree. Note the larvae.

Photo # 6670.

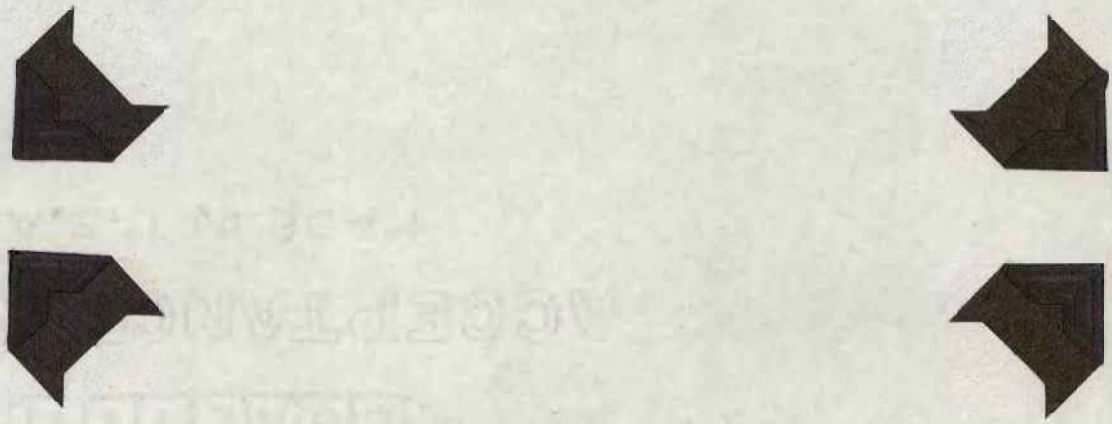


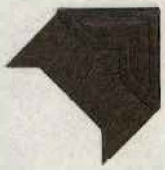
Photo # 6671.

Fig. 13

Gallery of *Eccoptogaster praecepe* Lec.

Fig. 14

Old attacks of *Eccoptogaster ventralis* Lec. partially healed (A) and new scars (B).



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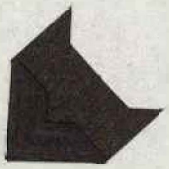
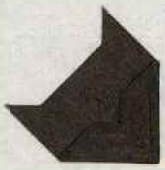




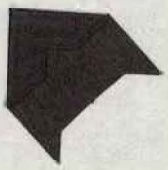


Photo # 6697

Fig. 15

Partially healed scars of Pseudohylesinus grandis Sw. Note the absence of a nuptial chamber.

Fig. 16

Old scars of Pseudohylesinus grandis Sw. (A) and new scars of Pityokteines elegans Sw. (B) Xeoptomaster ventralis Lec. (C) and Cerambycid (D).

Photo # 6702

Photo # 6698

Fig. 17

Butt of analyzed tree, showing galleries of *Platypus wilsoni* Sw.

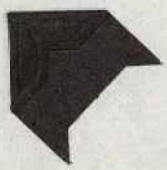



Photo # 6669


Fig. 18

Feeding of Ecoptogaster praeceps Lec. in twigs of white fir.

Fig. 19

Probable feeding of Ecoptogaster ventralis Lec.

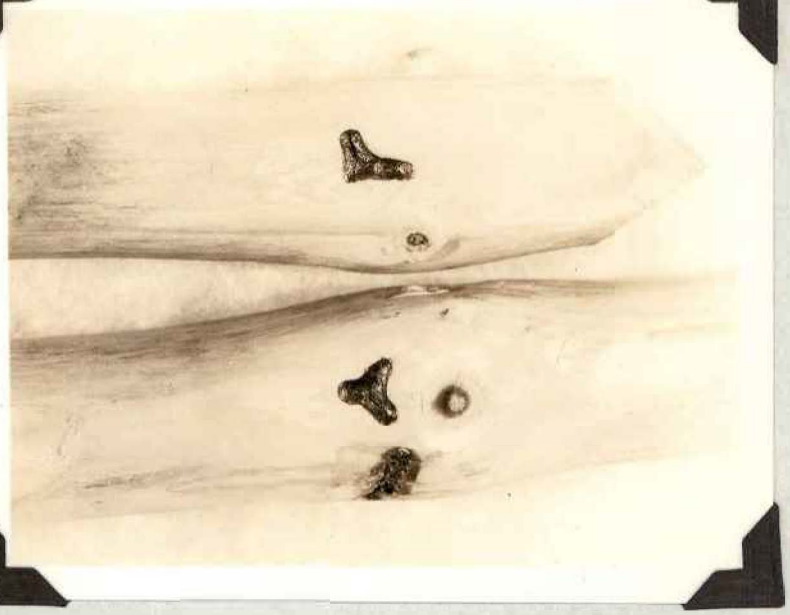


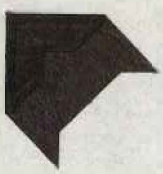
Photo # 6696

Fig. 20

Cross-section of white fir showing a gallery of Eccoptogaster ventralis Lec. in the process of healing.

Fig. 21

Gallery of Eccoptogaster ventralis Lec. completely healed. Gallery made in 1919.



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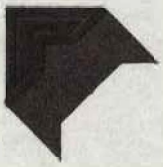


Photo # 6747

Fig. 22

Increment from log #1, five feet above base of tree. No growth after 1925. Note the small 1924 ring apparent in all sections.

Fig. 23

Increment from log #2, fifteen feet above base of tree. Showing cessation of growth in 1925.


25
22
21
1
6752


24
23
22
3

Fig. 24

Increment from log #8, fifty-five feet above base of tree. Showing very small ring in 1927.

Fig. 25

Increment from log #10, ninety-feet above base of tree. Growth ceased in 1927.


6
25
24
23
22
2

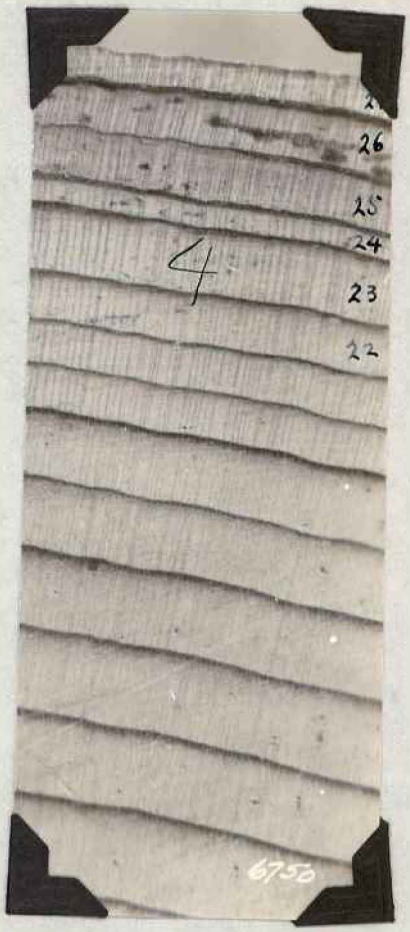
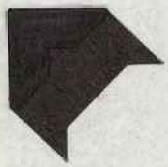
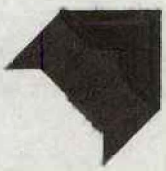

26
25
24
23
22
4
6750

Fig. 26

Increment from top of tree about 115 feet above base of tree. Only partial ring formed in 1927.





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